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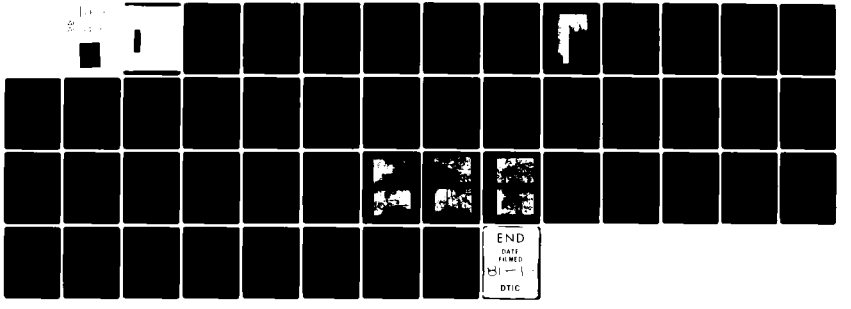

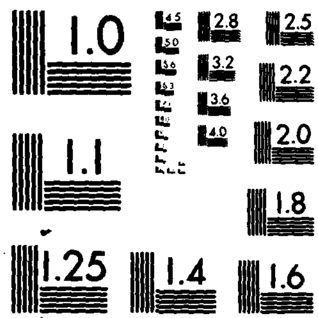

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20. Abstract

Pursuant to Public Law 92-367, Phase I Inspection Reports are prepared under guidance contained in the recommended guidelines for safety inspection of dams, published by the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general conditions of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

Based upon the field conditions at the time of the field inspection and all available engineering data, the Phase I report addresses the hydraulic, hydrologic, geologic, geotechnic, and structural aspects of the dam. The engineering techniques employed give a reasonably accurate assessment of the conditions of the dam. It should be realized that certain engineering aspects cannot be fully analyzed during a Phase I inspection. Assessment and remedial measures in the report include the requirements of additional indepth study when necessary.

Phase I reports include project information of the dam and appurtenances, all existing engineering data, operational procedures, hydraulic/hydrologic data of the watershed, dam stability, visual inspection report and an assessment including required remedial measures.

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the design flood should not be interpreted as necessarily posing a highly inadequate condition. The design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition, and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

CONTENTS

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Lake Arrowhead Dam
State: Virginia
County: Stafford
USGS 7.5 Minute Quadrangles: Storck, VA and Somerville, VA
Stream: Unnamed Tributary to Aquia Creek
Date of Inspection: 17 April 1980

BRIEF ASSESSMENT OF DAM

Lake Arrowhead Dam is an earthfill embankment approximately 26.3 feet high and 225 feet long, with a 65 foot wide vegetated earth emergency spillway located adjacent to the right abutment. The principal spillway is a 12 inch corrugated metal pipe acting as a riser. The dam, located approximately 9 miles northwest of Stafford, Virginia, is used for recreation. The dam is owned by the Lake Arrowhead Civic Association. Lake Arrowhead Dam is a "small" size - "significant" hazard structure as defined by the Recommended Guidelines for Safety Inspection of Dams.

Using the Corps of Engineers' screening criteria for initial review of spillway adequacy, the 100-year flood was selected as the spillway design flood (SDF). The SDF was routed through the reservoir and found to reach a maximum water surface elevation 2.6 feet below the top of the dam. The spillway is capable of passing up to 60 percent of the Probable Maximum Flood (PMF). The spillway is therefore adjudged as adequate.

The dam and appurtenant structures were found to be in generally poor overall condition. The embankment is heavily overgrown with trees and brush, major erosion has occurred in the emergency spillway, and several areas on the downstream toe and downstream face of the embankment contained turbid seepage suggesting possible piping potential. The dam is therefore assessed as unsafe, non-emergency.

Visual inspection and office analyses indicate deficiencies requiring further investigation and remedial treatment.

A qualified geotechnical engineering firm should be engaged to perform a detailed investigation and stability check of the dam. The owner is required to engage the services of a qualified geotechnical engineering firm within two months of the issuance of the approved Phase I inspection report. The

owner is required to have the consultant's report and to have reached an agreement with the state regarding required remedial measures within six months of the issuance of the approved Phase I inspection report.

All trees and brush growing on the dam and in the outwash deposit should be removed. Trees with a trunk diameter of 3 inches or less should be cut off at ground level; all trees with a trunk diameter greater than 3 inches should also have their root systems removed. The left side slope of the emergency spillway approach channel should be reconstructed and better defined. The erosion on the upstream embankment slope should be repaired and riprap should be installed near the waterline. A good grass cover should be established over the entire embankment and in the emergency spillway approach channel. The tree stumps, logs, and other debris in the emergency spillway discharge channel should be removed. The entire discharge channel should be widened, regraded, and provided with erosion protection. Grouted riprap may be necessary. A trash rack should be installed on the principal spillway riser. The driftwood in the pool below the principal spillway outlet structure should be removed, as should the vegetation overhanging the pool. A staff gage should be installed to monitor reservoir levels above normal pool.

A warning system and emergency action plan should be developed and put into operation.

MICHAEL BAKER, JR., INC.

Michael Baker, III, P.E.
Chairman of the Board and
Chief Executive Officer

COMMONWEALTH OF VIRGINIA
MICHAEL BAKER III
NO. 3176
CERTIFIED PROFESSIONAL ENGINEER

SUBMITTED: ORIGINAL SIGNED BY: JOHN H. SALLEY
for James A. Walsh, P.E.
Chief, Design Branch

RECOMMENDED: Original signed by JACK G. STARR
Jack G. Starr, P.E.
Chief, Engineering

APPROVED: Original signed by: Douglas L. Haller
Douglas L. Haller
Colonel, Corps of Engineers
District Engineer

Date: JUL 3 1980

OVERALL VIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM: LAKE ARROWHEAD DAM ID# VA 17908

SECTION 1 - PROJECT INFORMATION

1.1 General

1.1.1 Authority: Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of safety inspections of dams throughout the United States. The Norfolk District has been assigned the responsibility of supervising the inspection of dams in the Commonwealth of Virginia.

1.1.2 Purpose of Inspection: The purpose is to conduct a Phase I inspection according to the Recommended Guidelines for Safety Inspection of Dams. The main responsibility is to expeditiously identify those dams which may be a potential hazard to human life or property.

1.2 Description of Project

1.2.1 Description of Dam and Appurtenances: Lake Arrowhead Dam is an earthfill embankment approximately 26.3 feet high[1] and 225 feet long. The upstream and downstream embankment slopes are both approximately 3H:1V (Horizontal to Vertical). The crest of the dam is 29 feet wide. There is no information available on any possible zoning of the embankment. There is no slope protection present on the dam, and no evidence of an internal drainage system.

The principal spillway is a 12 inch corrugated metal pipe acting as a fixed crest riser. The downstream edge of the riser is located 29 feet from the upstream face of the embankment at normal pool, elevation 292.8 feet.[2] The principal spillway conduit is a 12 inch

[1]Measured from the streambed at the downstream toe to the embankment crest.
[2]All elevations are referenced to Temporary Bench Mark (T.B.M.) datum as estimated from the Somerville, Virginia, 7.5 minute USGS quadrangle. The T.B.M. was the top of the fire hydrant located on the crest of the dam.

corrugated metal pipe which discharges into the upstream end of Little Lake Arrowhead at the embankment toe.

The emergency spillway was cut through earth adjacent to the right[3] abutment. The approach channel has a trapezoidal cross section with a bottom width of 65 feet and side slopes of 8.5 H:1V and 2.5H:1V on the left and right sides, respectively. The control section is located on a two-lane macadam road which runs across the emergency spillway and along the crest of the dam. The lowest point on the control section is at elevation 294.3 feet. The emergency spillway discharge channel is irregularly shaped and poorly defined. The emergency spillway discharges into the upstream end of Little Lake Arrowhead immediately downstream of the dam.

There are no facilities for draining the reservoir.

1.2.2 Location: Lake Arrowhead Dam is located on an unnamed tributary to Aquia Creek, approximately 9 miles northwest of Stafford, Virginia. A Location Plan is included with this report.

1.2.3 Size Classification: The maximum height of the dam is 26.3 feet; the reservoir storage capacity at the crest of the dam (elevation 298.7 feet) is 347 acre-feet. Therefore the dam is in the "small" size category as defined by the Recommended Guidelines for Safety Inspection of Dams.

1.2.4 Hazard Classification: A two-lane macadam road which provides access to the residences around Lake Arrowhead runs along the dam crest; a similar road runs along the crest of Little Lake Arrowhead, approximately 1600 feet downstream. Both of these roads would probably be destroyed in the event of a dam failure by overtopping. There are 10 to 15 houses located around Little Lake Arrowhead, but they are well above the normal pool and probably would not suffer more than basement flooding in the event of a dam failure. Although loss of human life is not highly

[3]Facing downstream.

probable, appreciable economic losses due to the destruction of the two roads and basement flooding of the residences are likely in the event of a dam failure. Lake Arrowhead is therefore considered in the "significant" hazard category as defined by the Recommended Guidelines for Safety Inspection of Dams. The hazard classification used to categorize dams is a function of location only and has nothing to do with its stability or probability of failure.

1.2.5 Ownership: The dam is owned by the Lake Arrowhead Civic Association. The current secretary of the association is Mrs. K. M. Campbell, 133G Lake Arrowhead Drive, Stafford, Virginia 22554.

1.2.6 Purpose of Dam: The dam is used for recreation.

1.2.7 Design and Construction History: The dam was designed and constructed by Mr. H. Rylan Heflin. Construction of the dam was completed in 1959.

1.2.8 Normal Operational Procedures: The reservoir is normally operated at the crest of the principal spillway, elevation 292.8 feet. No formal operating procedures are followed for this structure. See Paragraph 4.1 for detailed operating procedures.

1.3 Pertinent Data

1.3.1 Drainage Area: The drainage area tributary to the dam is 0.65 square mile.

1.3.2 Discharge at Dam Site: The maximum discharge from the reservoir is unknown.

Principal Spillway:
Pool level at top of dam . . . . 7 c.f.s.

Emergency Spillway:
Pool level at top of dam . . . . 2503 c.f.s.

1.3.3 Dam and Reservoir Data: Pertinent data on the dam and reservoir are shown in the following table:

TABLE 1.1 DAM AND RESERVOIR DATA

Item	Elevation feet	Reservoir Capacity Area acres	Reservoir Capacity Acre-feet	Reservoir Capacity Watershed inches	Length feet
Top of dam (minimum)	298.7	43.2	347	10.0	3280
Emergency spillway crest	294.3	30.4	186	5.4	2610
Principal spillway crest (normal pool)	292.8	25.7	144	4.2	2380
Streambed at downstream toe of dam	272.4	-	-	-	-

SECTION 2 - ENGINEERING DATA

2.1 Design: Design plans, specifications, and boring logs were not available for use in preparing this report.

Geology of the Lake Arrowhead area is dominated by a reddish, very micaceous saprolite, possibly the weathering product of a schist or diamictite. Pavlides (1976) recognizes a "gritty to granular schist characterized by elongate quartz grains." Diamictite is a granite-like rock, massive, dark gray, non-stratified, and containing quartz lumps. The soil in the area is very shallow, normally less than a foot deep.

2.2 Construction: Construction records, as-built plans, and inspection logs were not available for review.

2.3 Evaluation: No stability analyses or hydrologic and hydraulic data were available for review. No construction records or as-built plans were available to adequately assess the condition of the dam. All evaluations and assessments in this report were based upon field observations, discussions with the owner, and office analyses.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

3.1.1 General: The field inspection was conducted on 17 April 1980. At the time of the inspection, the pool elevation was 293.0 feet; the tailwater elevation was 275.2 feet; the weather was mild and sunny with temperatures in the mid 50's°F. The ground surface at the embankment and abutments was generally dry. The dam and appurtenant structures at the time of inspection were found to be in fair to poor overall condition. Deficiencies found during the inspection will require further investigation and remedial treatment. The following are brief summaries of deficiencies found during the inspection. A Field Sketch of conditions found during the inspection is shown as Plate 1. The complete visual inspection check list is given in Appendix III. No record was found of any previous inspections.

3.1.2 Dam: The embankment was found to be in generally fair condition with no surface cracks or sloughs. The surface of the downstream slope is fairly uneven. Minor erosion has occurred on the upstream slope along the waterline and in an area where a fire hydrant with a line into the lake has been installed. The upstream slope is covered with brush and small trees; the downstream slope is covered with brush and small-to-medium size trees.

Approximately 1 gallon per minute of red water was seeping from a 15 foot wide section at the toe of the dam on the right side of the embankment. The sandy silt below this seep was soft and wet. A minor unmeasurable seep was located approximately 15 feet above the major seep. There was a minor red seep, too small to be measured, in the left downstream abutment/embankment contact 15 feet above the toe. Although no piping holes and soil accumulations were observed, the seeping water contained minute amounts of soil.

The junctions of the embankment and abutments appear to be in good condition except for the

minor seep in the left downstream abutment/ embankment contact. There is no evidence of significant erosion in these junctions, which are formed of vegetated earth with no riprap. The junction of the emergency spillway and dam is formed by a two-lane macadam road which runs across the spillway and along the crest of the dam; the junction appears to be in satisfactory condition.

3.1.3 Appurtenant Structures: The 12 inch corrugated metal pipe principal spillway riser and outlet structure appear to be in satisfactory condition. There is no trash rack on the riser. The outlet structure discharges into a small pool at the upper end of Little Lake Arrowhead. There is no riprap in the pool, which is partially overhung by brush and small trees. During the visual inspection it was observed that sediment and small pieces of driftwood have collected in the pool.

The emergency spillway approach channel is approximately 65 feet wide; the entrance to the approach channel is only a few inches above normal pool. The right side slope of the approach channel has a good cover of short grass; the bottom of the channel has a sparse cover of short grass, with many bare spots. The left side slope of the approach channel is gentle and poorly defined; vegetation on the left side slope consists of brush and small trees.

The control section of the emergency spillway is formed by a two-lane macadam road which crosses the spillway and runs along the crest of the dam. The control section appears to be in satisfactory condition.

The emergency spillway discharge channel downstream from the macadam road is moderately to severely eroded. Shallow gullies immediately downstream from the road have been partially filled with gravel and rubble to hinder erosion. Farther downstream, two large gullies are eroded to weathered bedrock and blocked with tree stumps, logs, and other debris. There is a short section of undisturbed ground between the two gullies. The slope at the downstream end of the discharge channel is extremely steep. An outwash deposit from

the emergency spillway has built up below the downstream end of the discharge channel. This deposit extends into Little Lake Arrowhead. The area of the deposit has a growth of small trees and brush, with puddles in erosion depressions.

3.1.4 Reservoir Area: The slopes around the reservoir are gentle, covered with light woods interspersed with grassy areas. The residual soil cover consists of reddish-brown silt and sand with some rock fragments. Weathered metamorphic bedrock is exposed in some areas. There is no evidence of significant erosion. There are private residences and small boat docks around the lake. Sedimentation does not appear to be significant.

3.1.5 Downstream Channel: Water from Lake Arrowhead flows directly into Little Lake Arrowhead, which is located immediately downstream. Little Lake Arrowhead is formed by waters impounded by an earth dam approximately 1500 feet downstream of Lake Arrowhead Dam. This downstream dam is approximately 24 feet high and 500 feet long. There is some driftwood along the shore at the upper end of the lower lake. An outwash deposit of silt, sand, and rock fragments, partially covered by brush and small trees, has formed below the emergency spillway discharge channel. There are 10 to 15 homes around the lower lake; all are at elevations well above flood stage.

3.1.6 Instrumentation: There was no instrumentation at the dam site at the time of the inspection.

3.2 Evaluation: In general, the dam and appurtenant structures are in fair to poor condition. The turbidity (red color) of the seepage may indicate the potential for piping of embankment material; a qualified geotechnical engineering firm should therefore be engaged to perform a detailed investigation and stability check of the dam. All trees and brush growing on the dam and in the outwash deposit should be removed. Trees with a trunk diameter of 3 inches or less should be cut off at ground level; all trees with a trunk diameter greater than 3 inches should also have their root systems removed. The left side slope of the emergency spillway approach channel should be reconstructed and better defined. The erosion on the upstream embankment slope should be repaired and riprap should be installed near

the waterline. A good grass cover should be established over the entire embankment and in the emergency spillway approach channel. The tree stumps, logs, and other debris in the emergency spillway discharge channel should be removed. The entire discharge channel should be widened, regraded, and provided with erosion protection. Grouted riprap may be necessary. A trash rack should be installed on the principal spillway riser. The driftwood in the pool below the principal spillway outlet structure should be removed, as should the vegetation overhanging the pool. A staff gage should be installed to monitor reservoir levels above normal pool.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures: Operation of the dam is an automatic function controlled by the principal spillway and the emergency spillway. Water entering the reservoir flows into the principal spillway at elevation 292.8 feet. When the inflow is sufficient, the reservoir level rises above elevation 294.3 feet and discharges through the emergency spillway.

4.2 Maintenance of Dam: Maintenance of the dam is the responsibility of the owner. An inspection or maintenance schedule has not been instituted.

4.3 Maintenance of Operating Facilities: There are no operating facilities at the dam.

4.4 Warning System: At the present time, there is no warning system or emergency action plan in operation.

4.5 Evaluation: Maintenance of the dam in the past has been inadequate. Regular inspections should be made of the dam and appurtenant structures. A thorough check list should be compiled for use by the owner's representative as a guide for the inspections. Maintenance items should be corrected annually. A warning system and emergency action plan should be developed and put into operation.

SECTION 5 - HYDRAULIC/HYDROLOGIC DATA

5.1 Design: No design data were available for use in preparing this report.

5.2 Hydrologic Information: No rainfall, stream gage, or reservoir stage records are maintained for this dam.

5.3 Flood Experience: No records were available. According to local residents, there is flow through the emergency spillway 2 or 3 times a year.

5.4 Flood Potential: The Probable Maximum Flood (PMF), 1/2 Probable Maximum Flood (1/2 PMF), and the 100-year flood were developed and routed through the reservoir by use of the HEC-1 DB computer program (Reference 9, Appendix IV) and appropriate unit hydrograph, precipitation, and storage-outflow data. Clark's T_c and R coefficients for the local drainage areas were estimated from basin characteristics. The rainfall applied to the unit hydrograph was taken from publications by the U.S. Weather Bureau and the National Oceanic and Atmospheric Administration (References 16 and 17, Appendix IV). Rainfall losses for the 100-year flood were estimated at an initial loss of 1.5 inches and a constant loss rate of 0.15 inch per hour thereafter. An initial loss of 1.0 inch and a constant loss rate of 0.05 inch per hour were used for the PMF.

5.5 Reservoir Regulation: Pertinent dam and reservoir data are shown in Table 1.1, Paragraph 1.3.3.

Regulation of flow from the reservoir is automatic. Normal flows are maintained by the crest of the principal spillway riser at elevation 292.8 feet. Water also flows past the dam through the ungated emergency spillway in the event water in the reservoir rises above an elevation of 294.3 feet.

Outlet discharge capacity was computed by hand; reservoir area was planimetered from the Somerville and Storck, Virginia, 7.5 minute USGS quadrangles; and storage capacity was computed by the HEC-1 DB program. All flood routings were begun with the reservoir at normal pool. Flow through the principal spillway was included in the routings.

5.6 Overtopping Potential: The probable rise of the reservoir and other pertinent information on reservoir performance are shown in the following table:

TABLE 5.1 RESERVOIR PERFORMANCE

Item	Normal(a)	Hydrographs: 100-year flood	Hydrographs: 1/2 PMF	Hydrographs: PMF(b)
Peak flow, c.f.s.				
Inflow	1	977	2686	5372
Outflow	1	444	2103	4618
Peak elev., ft.	293.0	296.1	298.3	300.1
Emergency spillway (c) (elev. 294.3 feet)				
Depth of flow, ft.	-	1.8	4.0	5.8
Average velocity, f.p.s.	-	6.2	9.3	11.2
Duration of flow, hrs.	-	22.8	41.3	51.5
Non-overflow section (c) (elev. 298.7 ft.)				
Depth of flow, ft.	-	-	-	1.4
Average velocity, f.p.s.	-	-	-	5.5
Total duration of over-topping, hrs.	-	-	-	1.8
Tailwater elev., ft.	275.2	-	-	-

(a) Conditions at time of inspection.
(b) The PMF is an estimate of flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in a region.
(c) Velocity estimates were based on critical depth at control section.

5.7 Reservoir Emptying Potential: There are no facilities for draining the reservoir.

5.8 Evaluation: Lake Arrowhead Dam is a "small" size - "significant" hazard dam requiring evaluation for a spillway design flood (SDF) in the range between the 100-year flood and the 1/2 PMF. Because of the risk involved, the 100-year flood has been selected as the SDF. The 100-year flood was routed through the reservoir and found to reach a maximum water surface elevation 2.6 feet below the top of the dam. The spillway is capable of passing up to 60 percent of the PMF.

Conclusions pertain to present day conditions and the effect of future development on the hydrology has not been considered.

SECTION 6 - DAM STABILITY

6.1 Foundation and Abutments: There is no information available on the foundation conditions. The dam is located on the Fall Line of the Coastal Plain of Virginia. The predominate deposit in the area is a reddish, very micaceous saprolite, possibly the weathering product of a schist or diamictite. Diamictite is a granite-like rock, massive, dark gray, non-stratified, and containing quartz lumps. This deposit is exposed in two deep erosion gullies in the discharge channel of the emergency spillway. No internal drainage system was observed. How the dam is keyed into the foundation is unknown. As noted in the visual inspection, there are seeps and wet areas on and below the downstream embankment.

6.2 Embankment

6.2.1 Materials: There is no information available on the nature of the embankment materials. The area soils are generally silty or clayey sands.

6.2.2 Stability: There are no available stability calculations. The dam is 26.3 feet high and the crest is 29 feet wide. It has an estimated upstream slope of 3H:1V and a measured downstream slope of 3H:1V. The dam is not subject to a sudden drawdown because there are no facilities for dewatering the reservoir.

According to the guidelines presented in Design of Small Dams by the U.S. Department of the Interior, Bureau of Reclamation, for small homogeneous dams with a stable foundation, not subjected to a drawdown, and composed of silty or clayey sands (SM, SC); the recommended slopes are 2.5H:1V upstream and 2H:1V downstream. The recommended crest width is 16 feet. Based on these guidelines, the dam has adequate embankment slopes and width.

6.2.3 Seismic Stability: Lake Arrowhead Dam is located at the borderline of Seismic Zones 1 and 2. Therefore, according to the Recommended Guidelines for Safety Inspection of Dams, the dam is considered to have no hazard from earthquakes provided static stability conditions are satisfactory and conventional safety margins exist.

6.3 Evaluation: There is insufficient information to adequately evaluate the stability of the dam. Based on the Bureau of Reclamation guidelines, the width and slopes of the embankment are adequate. However, the visual inspection revealed seeps and wet areas at the downstream toe and on the downstream face of the embankment. Although no piping holes or soil accumulations were observed, these seeps were red in color and contained minute amounts of soil. A qualified geotechnical engineering firm should therefore be retained to perform a detailed investigation and stability check of the dam.

The spillway passes the design flood with a maximum water surface elevation 2.6 feet below the top of the dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment: There were no engineering data available for use in preparing this report. Deficiencies discovered during the field inspection and office analyses will require further investigation and remedial treatment. The dam and appurtenant structures are generally in fair to poor condition. Maintenance of the dam is considered inadequate.

Using the Corps of Engineers' screening criteria for initial review of spillway adequacy, the 100-year flood was selected as the SDF for the "small" size - "significant" hazard classification of Lake Arrowhead Dam. It has been determined that the spillway would pass the SDF with a maximum water surface elevation 2.6 feet below the top of the dam. The spillway is capable of passing up to 60 percent of the PMF and is adjudged as adequate.

The dam and appurtenant structures were found to be in generally poor overall condition. The embankment is heavily overgrown with trees and brush, major erosion has occurred in the emergency spillway, and several areas on the downstream toe and downstream face of the embankment contained turbid seepage suggesting possible piping potential. The dam is therefore assessed as unsafe, non-emergency.

There is no warning system or emergency action plan currently in operation.

7.2 Recommended Remedial Measures: A qualified geotechnical engineering firm should be engaged to perform a detailed investigation and stability check of the dam. The owner is required to engage the services of a qualified geotechnical engineering firm within two months of the issuance of the approved Phase I inspection report. The owner is required to have the consultant's report and to have reached an agreement with the state regarding required remedial measures within six months of the issuance of the approved Phase I inspection report.

All trees and brush growing on the dam and in the outwash deposit should be removed. Trees with a trunk diameter of 3 inches or less should be cut off at ground level; all trees with a trunk diameter greater than 3 inches should also have their root systems removed. The left side slope of the emergency spillway

approach channel should be reconstructed and better defined. The erosion on the upstream embankment slope should be repaired and riprap should be installed near the waterline. A good grass cover should be established over the entire embankment and in the emergency spillway approach channel. The tree stumps, logs, and other debris in the emergency spillway discharge channel should be removed. The entire discharge channel should be widened, regraded, and provided with erosion protection. Grouted riprap may be necessary. A trash rack should be installed on the principal spillway riser. The driftwood in the pool below the principal spillway outlet structure should be removed, as should the vegetation overhanging the pool. A staff gage should be installed to monitor reservoir levels above normal pool.

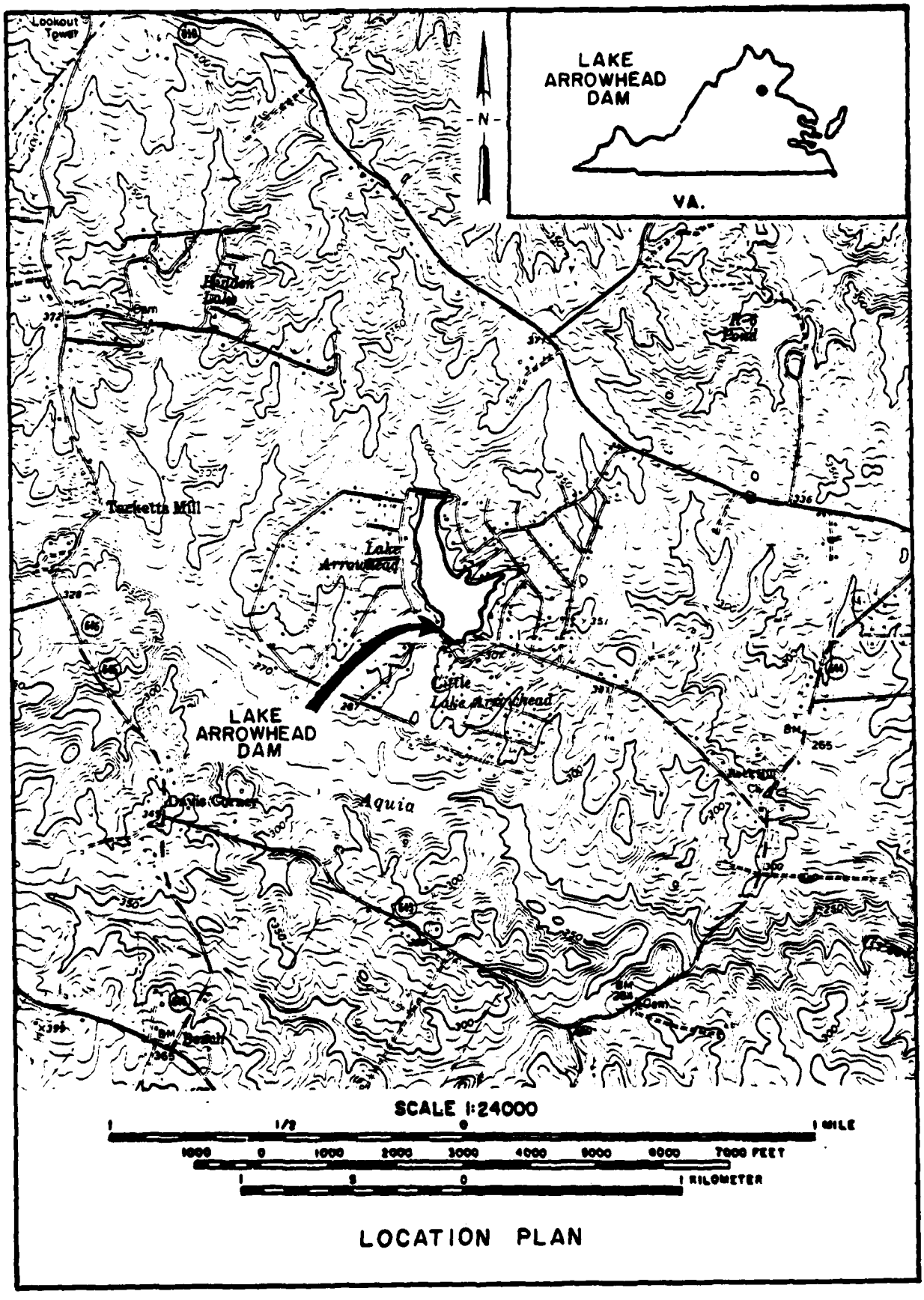
A warning system and emergency action plan should be developed and put into operation.

APPENDIX I

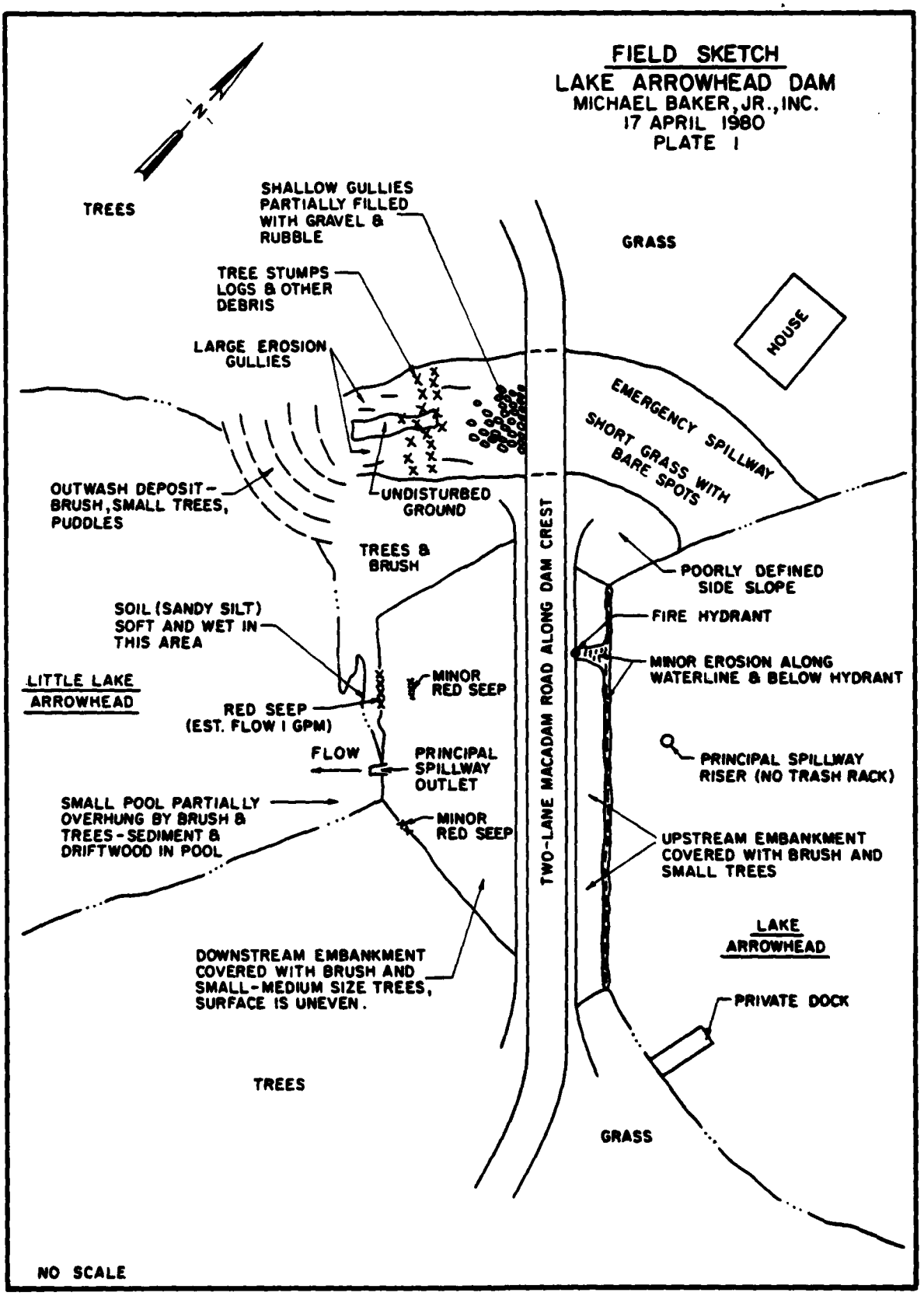
PLATES

CONTENTS

NAME OF DAM: LAKE ARROWHEAD DAM



LOCATION PLAN


FIELD SKETCH
LAKE ARROWHEAD DAM
MICHAEL BAKER, JR., INC.
17 APRIL 1980
PLATE 1
N
TREES
SHALLOW GULLIES PARTIALLY FILLED WITH GRAVEL & RUBBLE
GRASS
TREE STUMPS LOGS & OTHER DEBRIS
HOUSE
LARGE EROSION GULLIES
EMERGENCY SPILLWAY
SHORT GRASS WITH BARE SPOTS
OUTWASH DEPOSIT - BRUSH, SMALL TREES, PUDDLES
UNDISTURBED GROUND
TREES & BRUSH
POORLY DEFINED SIDE SLOPE
SOIL (SANDY SILT) SOFT AND WET IN THIS AREA
FIRE HYDRANT
MINOR EROSION ALONG WATERLINE & BELOW HYDRANT
LITTLE LAKE ARROWHEAD
MINOR RED SEEP
RED SEEP (EST. FLOW 1 GPM)
FLOW
PRINCIPAL SPILLWAY OUTLET
PRINCIPAL SPILLWAY RISER (NO TRASH RACK)
SMALL POOL PARTIALLY OVERHUNG BY BRUSH & TREES - SEDIMENT & DRIFTWOOD IN POOL
MINOR RED SEEP
TWO-LANE MACADAM ROAD ALONG DAM CREST
UPSTREAM EMBANKMENT COVERED WITH BRUSH AND SMALL TREES
LAKE ARROWHEAD
DOWNSTREAM EMBANKMENT COVERED WITH BRUSH AND SMALL-MEDIUM SIZE TREES, SURFACE IS UNEVEN.
PRIVATE DOCK
TREES
GRASS
NO SCALE

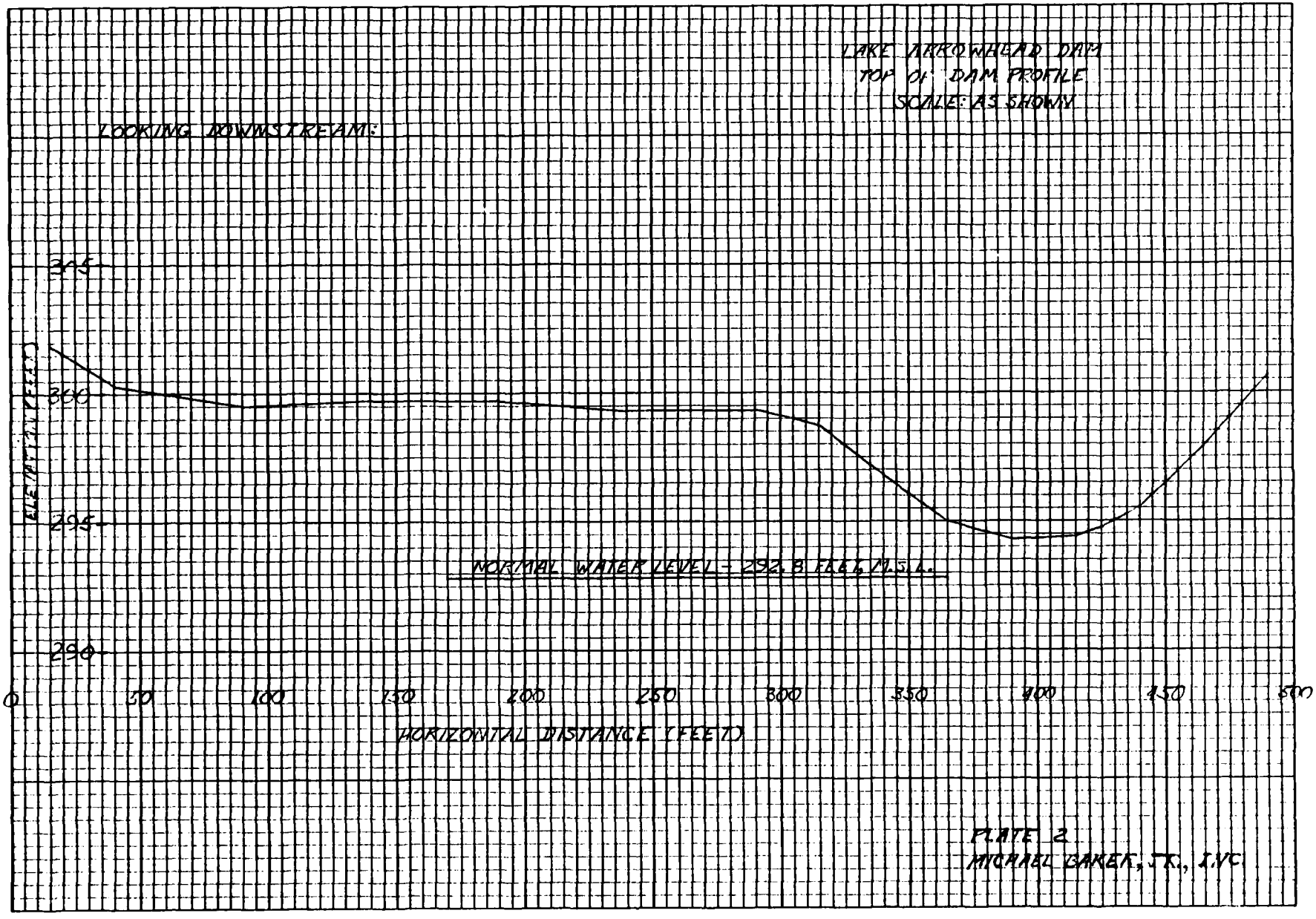


PLATE 2
MICHAEL BAKER, JR., INC.

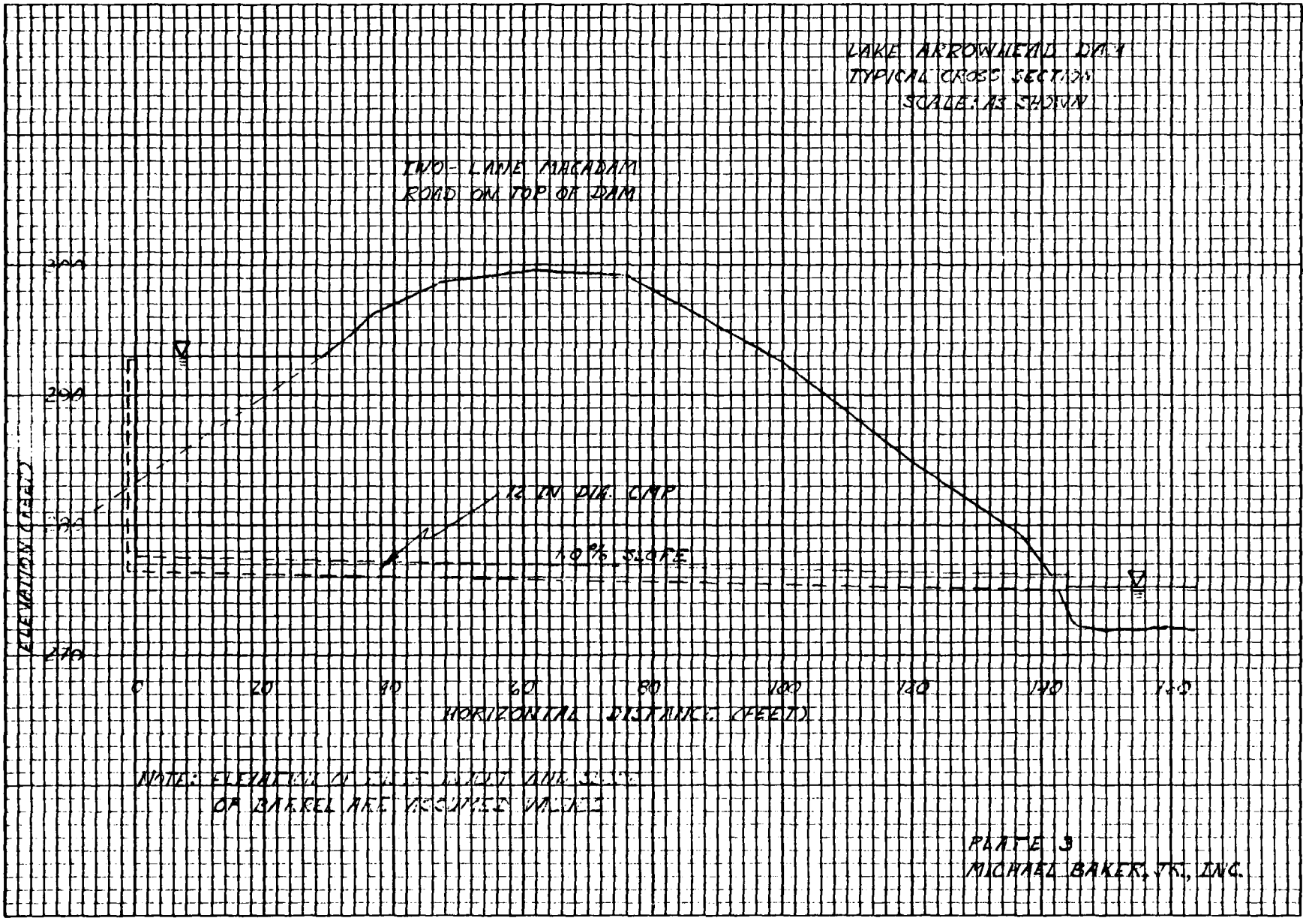


PLATE 3
MICHAEL BAKER, JR., INC.

APPENDIX II

PHOTOGRAPHS

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Note: Photographs were taken on 17 April 1980.

LAKE ARROWHEAD DAM

PHOTO 1. Upstream Slope (Emergency spillway approach channel at far right)

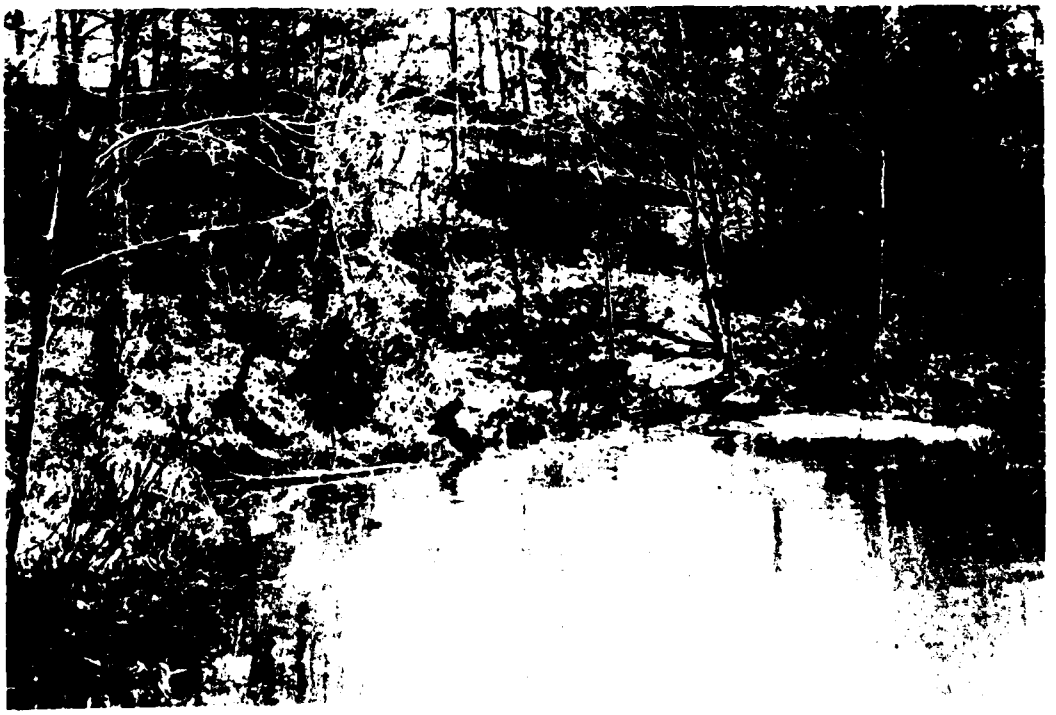

PHOTO 2. Downstream Slope

PHOTO 3. Principal Spillway Outlet

PHOTO 4. Debris in Emergency Spillway Discharge Channel

PHOTO 5. Seep at Toe of Dam on Right Side of Slope

PHOTO 6. Downstream Area (Little Lake Arrowhead)

APPENDIX III

VISUAL INSPECTION CHECK LIST

Phase I
Visual Inspection
Check List

Name of Dam Lake Arrowhead Dam County Stafford State Virginia Coordinates Lat. 3830.0
Long. 7732.7

Date of Inspection 17 April 1980 Weather Sunny Temperature 55° F.

Pool Elevation at Time of Inspection 293.0 ft. T.B.M. Tailwater at Time of Inspection 275.2 ft. T.B.M.

III-1

Inspection Personnel:

Michael Baker, Jr., Inc.:

Jeffrey A. Quay
Jeffrey S. Maze
William L. Sheafer

Virginia State Water Control Board:

Edwin B. Constantine, III
Timothy Perry
Andrew Pare

Owner's Representatives:

None

William L. Sheafer Recorder

EMBANKMENT

Name of Dam LAKE ARROWHEAD DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed	
EMBANKMENT AND ABUTMENT SLOPES	Minor erosion has occurred on the upstream slope along the waterline and in an area where a fire hydrant with a line into the lake has been installed. Other than this, no sloughing or significant erosion was found on the embankment or abutments. The surface of the downstream slope is fairly uneven.	The erosion on the upstream slope should be repaired and riprap should be installed near the waterline.

EMBANKMENT

Name of Dam LAKE ARROWHEAD DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Vertical and horizontal alignment of the crest appears to be satisfactory. A two-lane macadam road runs along the crest of the dam.	
RIPRAP FAILURES	There is no riprap on the dam or appurtenant structures.	Riprap should be installed on the upstream face near the waterline and in the discharge channel of the emergency spillway.
VEGETATION	The upstream slope is covered with brush and small trees. The downstream slope is covered with small-to-medium size trees and brush. The emergency spillway approach channel has a sparse cover of short grass. There is no vegetation in the emergency spillway discharge channel.	All brush and trees with a trunk diameter of less than 3 in. should be cut off at ground level. All trees with a trunk diameter greater than 3 in. should also have their root systems removed. After this is done, a good grass cover should be established. The emergency spillway discharge channel should be riprapped.
EMBANKMENT MATERIALS	The dam was appraently constructed of reddish brown silt and sand with rock fragments and mica flakes.	No construction records or information on embankment materials are available for review.

EMBANKMENT

Name of Dam LAKE ARROWHEAD DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	The junctions of the embankment and abutments appear to be in good condition except for a small seep in the left downstream abutment/embankment contact 15 ft. above the toe. There is no evidence of significant erosion in these junctions, which are formed of vegetated earth with no riprap. The junction of the emergency spillway and dam is formed by a two-lane macadam road which runs across the spillway and along the crest of the dam; the junction appears to be in satisfactory condition. The emergency spillway discharge channel is severely eroded and blocked with debris.	See the sections of this check list entitled "ANY NOTICEABLE SEEPAGE" and "DISCHARGE CHANNEL".
ANY NOTICEABLE SEEPAGE	Approximately 1 g.p.m. of red water seeps from a 15 ft. wide section at the toe of the dam on the right side of the embankment. The sandy silt below this seep is soft and wet. A minor unmeasurable seep is located approximately 15 ft. above the major seep. There is a minor red seep, too small to be measured, in the left downstream abutment/embankment contact 15 ft. above the toe. Although no piping holes or soil accumulation were observed, the seeping water contained minor amount of soil.	The red color of the seepage indicates a small amount of turbidity and the potential for piping of embankment material. A qualified geotechnical engineering firm should therefore be engaged to perform a detailed investigation and stability check of the dam.
STAFF GAGE AND RECORDER	None observed	A staff gage should be installed to monitor reservoir levels above normal pool.
DRAINS	No evidence of an internal drainage system was found during the inspection.	

OUTLET WORKS

Name of Dam: LAKE ARROWHEAD DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Not Applicable	
INTAKE STRUCTURE	The intake structure is a vertical section of 12 in. diameter C.M.P. acting as a riser. There is no trash rack on the riser. The riser appears to be in satisfactory condition.	A trash rack should be installed.
OUTLET STRUCTURE	The outlet structure is a 12 in. diameter C.M.P. which protrudes from the downstream embankment at the toe with no visible supporting structure except some rock around the mouth of the outlet. The outlet appears to be in satisfactory condition.	
OUTLET CHANNEL	The outlet structure discharges into a small pool at the upper end of Little Lake Arrowhead. There is no riprap in the pool. The pool is partially overhung by brush and small trees. Sediment and small pieces of driftwood have collected in the pool.	The driftwood and overhanging vegetation should be removed.
EMERGENCY GATE	There are no facilities for draining the reservoir.	

EMERGENCY SPILLWAY

Name of Dam: LAKE ARROWHEAD DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONTROL SECTION	The control section of the emergency spillway is formed by a two-lane macadam road which crosses the spillway and runs along the crest of the dam. The control section appears to be in satisfactory condition.	According to local residents, there is flow through the emergency spillway 2 or 3 times a year.
APPROACH CHANNEL	The approach channel is approximately 65 ft. wide; the entrance to the approach channel is only a few in. above normal pool. The right side slope has a good cover of short grass; there is a house at the top of this slope. The bottom of the channel has a sparse cover of short grass, with many bare spots. The left side slope is gentle and poorly defined; it merges with the embankment. Vegetation on the left side slope consists of brush and small trees.	A good cover of short grass should be established throughout the approach channel. The left side slope should be reconstructed and better defined.
DISCHARGE CHANNEL	The channel downstream of the macadam road in the spillway is moderately to severely eroded. Shallow gullies immediately downstream from the road have been partially filled with gravel and rubble to hinder erosion. Farther downstream, two large gullies are eroded to weathered bedrock and blocked with tree stumps, logs, and other debris. There is a short section of undisturbed ground between the two gullies. The slope at the downstream end of the discharge channel is extremely steep. An outwash deposit from the emergency spillway has built up below the downstream end of the discharge channel. This deposit extends into Little Lake Arrowhead. The area of the deposit has a growth of small trees and brush, with puddles in erosion depressions.	The entire discharge channel should be widened, regraded, and provided with erosion protection. Grouted riprap may be necessary. The tree stumps, logs, and other debris in the channel should be removed, as should the trees and brush growing in the outwash deposit.

INSTRUMENTATION

Name of Dam: LAKE ARROWHEAD DAM

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	No permanent markers were found.	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER	None	

RESERVOIR

Name of Dam: LAKE ARROWHEAD DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	The slopes around the reservoir are gentle, covered with light woods intersparsed with grassy areas. The residual soil cover consists of reddish-brown silt and sand with some rock fragments. Weathered metamorphic bedrock is exposed in some areas. There is no evidence of significant erosion. There are private residences and small boat docks around the lake.	
SEDIMENTATION	Sedimentation does not appear to be significant.	

DOWNSTREAM CHANNEL

Name of Dam: LAKE ARROWHEAD DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Water from Lake Arrowhead discharges directly into Little Lake Arrowhead located immediately downstream. There is some driftwood along the shore at the upper end of the lower lake. An outwash deposit of silt, sand, and rock fragments, partially covered by brush and small trees, has formed below the emergency spillway discharge channel.	
SLOPES	The slopes around the lower lake are gentle to moderately steep and are covered with woods intersparsed with grassy areas. There is no evidence of significant erosion. There are private residences and small boat docks around the lower lake.	
APPROXIMATE NO. OF HOMES AND POPULATION	There are 10 to 15 homes around the lower lake; all are at elevations well above flood stage.	There is no serious danger of loss of life in the event of a dam failure by overtopping.

APPENDIX IV

GENERAL REFERENCES

GENERAL REFERENCES

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